Applicability and Adaptability of Gait-based Biometric Security System in GCC

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Abstract
Robust system may not guaranty its applicability and adaptability. That is why research and development go together in the modern research concept. In this paper we are going to examine the applicability and adaptability of gait-based biometric identity verification system especially in the GCC (Gulf Cooperation Council). The system itself closely involved with human interaction where privacy and personality are in concern. As of 1st phase of our research we will establish gait-based identity verification system and then we will explain them ***in and out*** of human interaction with the system. With involved interaction we will conduct an extensive literature review to find out both applicability and adoptability of the system. To conduct our experiment, we will use UCMG databased which is readily available for the research community with more than three thousand video sequences in different viewpoint collected in various walking pattern and clothing. In the literature review we covered approach of data collection, potential traits to collect and possible consequences along with the general literature of this research. For analyzing gait biometric trait, we will apply multivariate statistical classifier through well-known machine learning algorithms in a ready platform. The finding will act as path-way for future research along with the perception of the user for such system especially in GCC.

Keywords: *Biometric, Identity verification, Classifier, Machine learning*

1. Introduction

Biometric identification, biometric identity verification system and access control system through biometric trait are well known and well established for last couple of decades. It has been running without major intervention. It has well popularity in private to public sector, individual to organization. Over the time, the need of robust system came in place due to a number valid reasons e.g. alteration of biometric trait, volatile nature of biometric trait. To find out the solution researchers came-up with a number approaches which will serve the purpose of identification or identity verification over the ages even though the subject/people wats to hide themselves. Again it took place and applied in various area of business including daily life of a person. No question on the robustness, no arguments on adoptability, but question is arising on the applicability. This is mostly due to privacy and confidentiality. General finger print is well accepted across the border, but face recognition is also sometime difficult due to various reasons. However, that is also well established. Not much restriction in applicability and adoptability in those biometric trait. Over the time some advanced and non-intrinsic biometric trait came-in e.g. example gait biometric which not very powerful in terms of accuracy, but when it combines with any other common and soft biometric it is becoming powerful and robust. Gait biometric by its nature and non-intrinsic, but it is very easy to trace from long distance. One of most prodigy of this biometric is; we can identify without use involvement. Conversely, there is the problem. People from different country, different culture and different law are not or may not allow to deploy such biometric identification or verification system. As we stated earlier the main concern is the personal privacy and confidentiality. In this research we are aiming to do an extensive survey especially in GCC country to check the adoptability and acceptability of such system.

2. Background

Applicability and acceptability of biometric identity verification system still in question mark due to cultural differences, knowledge on the system[1], different perception etc. Because of such constraints a number good system or proposal stuck and put-aside e.g. gait-based identity verification [2] in immigration check point. Even though it is well established concept for identity verification; but not implemented across the border due to the stated constraints. Similarly, some other challenge like

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external attack on user interface and template database [3]. In this case there is high chance of discloser of physiological trait which will surely attack on individual privacy. Such facts are having vast effect on decision maker to decide applying biometric control system or biometric based identity verification system. Some region or country very much concern in privacy of their citizen other than security or equality with security [4]. On the other side some are very much concern about security other than privacy. In [5] an extensive elaboration authors highlighted a lot on the need of security instead of privacy. They also suggested to combine a number of biometric traits to make it more reliable and robust. Similarly considering other possible variables also highlighted to make the authentication protocol. Future of biometric based identity verification is also extensively promoted to serve for the future and digital world. Not by ignoring privacy but by providing uprising demand of security system using biometric trait has been reported by the researchers [6] where investment in biometric security solution and widespread of usability and scope clearly reported.

In another research [7] researchers proposed combination of cryptography and biometric trait to make the authentication system more secure and reliable. Even though privacy is a vital concern but security becoming in first phase. In this research, researchers suing biometric attribute to generate some art of cryptographic key which are in fact working as robust output to identify or authenticate a person or object. Further, looking into the case-area GCC; researcher [8] identified three basic area of application of biometric identity verification in Saudi Arabia where they are mostly applying for e-government and mobile security. Low of its application is also considering as driving force to apply in Saudi Arabia. One of significance of this research is they are proposing a comprehensive framework of application where security, convenience, efficiency and privacy are taken care off. Another very popular application biometric identity verification in GCC is attendance management system. Taking and managing attendance using biometric trait is very popular like other developed region in the world. A number of areas also highlighted [9] where they are running and applying the system without any remarkable intervention. Mostly they are using in managing attendance, possible integration using biometric, measuring data security followed by analysis and reporting.

Furthermore, one of significant report came across where a widespread elaboration on biometric system especially in GCC accumulated. After comprehensive research and analysis, they concluded with some number of realistic and timely key findings. Curtailing government surveillance due to data protection and regulations. It also highlighted that mandatory ID scheme has modernized with the emphasized lacking [10]. Involved risk with the general biometric trait that are using in common biometric systems is massively elucidated. Researcher in Oman also conducted an impressive research where they highlighted a number factor of biometric application and its implication towards the society and their citizen [3]. Long range biometric trait i.e. gait is not significantly highlighted.

In general, biometric application is well acceptable worldwide which is already proven and extensive research and implementations are also taken place. But the GCC is little different especially in terms of application. Mostly they (but not all) they are using biometric application where general and common biometric trait is involved in identification or authentication for general ID-card, motor card (driving license or car registration), attendance management and health card [8-10] etc. Applying biometric based security system for national security or homeland security in large prospect yet to get acceleration is some extend. This research; will act to identify the gap and uphold the importance of application in large extend followed by set of experiments where gait based biometric system potentially expecting to work to solve the identified concern in GCC.

3. Methodology

For all our experiments set of renowned methods has been applied. On dimensionality reduction and Eigen-value extraction, we castoff principle component analysis (PCA) and linear discriminant analysis (LDA). To identify a person from extracted Eigen-value, we castoff most powerful mathematical-function "multilayer perceptron (MLP)".

***Principle Component Analysis**:* Principle component analysis is a very prominent algorithm especially in machine learning for identifying data pattern and visualize the similarities and differences of those data. In general, it is always difficult to find data with expected dimension. Some time it is more high resolution or sometime it is high graphics or poor graphics. To this extend our proposed algorithm PCA is a powerful tool for analyzing data. One of very attractive reason for selecting PCA is ability of data-compress. All most all types of data can be compressed using PCA. It is basically working through reducing the number of dimensions without sacrificing much on the data quality or by keeping the same information within the data. Perhaps; this technique is very popular in image compression [11]. In the image analysis it works like;

X=(x1, x2, x3……N2)…….(1)

where the rows of pixels in the image are placed one after the other to form a one dimensional image. Each image is N pixels high by N pixels wide. For each image it creates an image vector. And then it counts all the images together in one big image-matrix like;

Matrix = (v1, v2, v3……vN)…… (2)

Linear Discriminant Analysis: Another effective algorithm is LDA (Linear discriminant analysis) which works almost in the same phase of PCA (principal component analysis). When it comes for dimensionality reduction; both algorithms look for linear combinations of variables which is in fact explain the data in better manner. However, little difference is there and that what made us to use LDA for this research in all experiments. It will open door for us to compare and suggest the optimum one for such research. Likewise, LDA explicitly attempts to model the difference between the classes of data. PCA on the other hand does not take into account any difference in class, and factor analysis builds the feature combinations based on differences rather than similarities. There is also some difference observed between discriminant analysis and factor analysis as this is not an interdependence technique: a dissimilarity between dependent variables and independent variables (also called criterion variables) must be occurred. LDA works when the dimensions made on independent variables for each observation are unceasing quantities. In the time of dealing with categorical independent variables, the equivalent technique is discriminant correspondence analysis [12].

Multilayer Perceptron (MLP): Along with two prominent algorithms based on our previous experience with such experiments we straight-way move forward to Multi-Layer perceptron (MLP) which is a feed forward neural network with one or more layers between input and output layer. Eventually it works in same directional flow from input to output layer (forward); that is why this is called feed-forward approach. This type of network is trained with the back-propagation learning algorithm. Further, multilayer perceptron (MLP) is used in a wide range area especially for pattern classification, recognition, prediction and approximation. Multi-Layer Perceptron also used to solve difficulties which are not linearly separable [13]. In this experiment around 800 hidden layer took place for each of dataset where we had 49 input layer and 50 output layer. This is mostly depending on proportions, occurrences and the classes of the dataset. Next section below explaining the details of our experiments and abstract analysis.

4. Experiments and Analysis

For experimental evaluation we used UCMG-Gait-Database [14]. The University of Canberra Multimodal Gait Database (UCMG-Database) has developed in University of Canberra in mid-2013. It has developed as partial fulfilment of my PhD degree under School of Information Technology and Engineering, Faculty of ESTeM. This is the database 1st in Australia of its kind, which is open for research community in this area or related filed where the extracted data can be applied as a potential trait to experiment. Multiple instances for a single data is captured in various viewpoints using various walking style and clothing including some possible variations in walking i.e. (i) normal walking, (ii) fast walking, (iii) walking with heavy bag, (iv) walking with overcoat (long jacket), (v) walking with hat, (vi) walking with hoody and (vii) walking with mask. All theses of sequences have captured with four (4) different cameras in four (4) different. More than hundred (100) individual and around three thousand (3000) of different video-sequence contains in the UCBM-Database. In our research laboratory we have examine most of the dataset (sample) that has described as follows;

For the experiments we have taken dataset from 275 degree view point in number of pattern like; normal walking, fast walking, walking with hat, walking with long jacket, walking with mask, data taken real world CCTV. In total 11 dataset (person) processed for this experiment. In all dataset we have taken same people. Each people has 16 images, therefor we experimented 880 images for this experiment. Table 1 shows the accuracy of identification

Table 1: Identification with LDA-MLP

No	Dataset	Number of Image	Accurate Identification (%)
1	Normal walking	880	100%
2	Fast Walking	880	100%
3	Walking with Overcoat	880	100%
4	Walking with Hat	880	100%
5	Walking with Mask	864	100%

We tried to find out what are the variations if a person changes the walking style, dress and appearance. By using mentioned algorithm and classifier we received equally 100% correction rate in detecting a person accurately. One most ground-braking finding of this experiment is; to identify a person even they are using mask to cover their complete head. we received 100% correct detection in even if people using mask. Figure 1 and 2 shows the Eigen face and PCA eigen value.

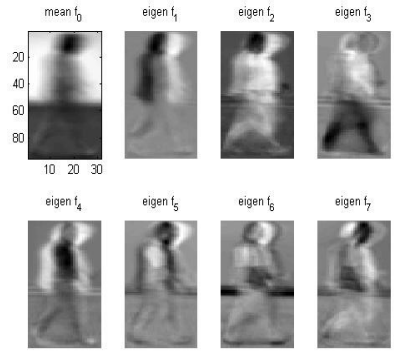


Figure 1: Eigen Face for normal walking pattern

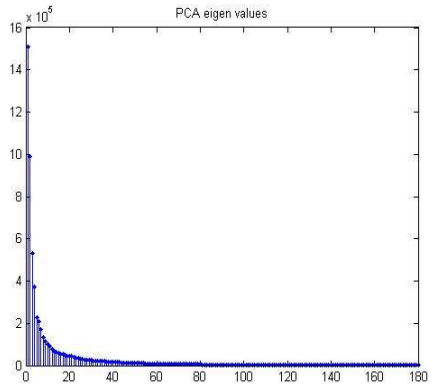
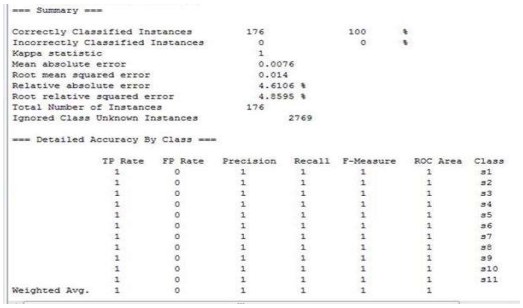


Figure 2: PCA Eigen Value for fast-walking Pattern

Subsequently successful 1st experiment, we moved to 2nd experiment with the data extracted from real world CCTV. In total same number of (11) people were involved and equal number of (880) sample image applied to this experiment. 40% of the data we trained and rest 60% used for testing. In this experiment we also received surprising result. Figure 3 showing the result of the data taken from CCTV footage.



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=== Summary ===

Correctly Classified Instances         176               100      %
Incorrectly Classified Instances         0                 0      %
Kappa statistic                          1
Mean absolute error                      0.0076
Root mean squared error                  0.014
Relative absolute error                  4.6106 %
Root relative squared error              4.8595 %
Total Number of Instances              176
Ignored Class Unknown Instances                2769

=== Detailed Accuracy By Class ===

               TP Rate   FP Rate   Precision   Recall  F-Measure   ROC Area  Class
                 1         0          1         1         1          1        s1
                 1         0          1         1         1          1        s2
                 1         0          1         1         1          1        s3
                 1         0          1         1         1          1        s4
                 1         0          1         1         1          1        s5
                 1         0          1         1         1          1        s6
                 1         0          1         1         1          1        s7
                 1         0          1         1         1          1        s8
                 1         0          1         1         1          1        s9
                 1         0          1         1         1          1        s10
                 1         0          1         1         1          1        s11
Weighted Avg.    1         0          1         1         1          1
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Figure 3: Result Summary of CCTV Footage

As we can see from above figure, we tested 11 people, 16 images each, in total 176 instances. And function MLP identified all 176 correctly. It is also remarkable that true positive and false positive rate 1 and 0 accordingly. However, after getting wonderful from CCTV footage, we move our final experiment. In this experiment we tested a person in three clear traits that ear-side face and gait. In total for 11 people 880 images taken for experiment. Out 880 images, 40% used training and rest of them used for testing. Initially we experimented with clear ear and side face. we received 100% correct detection rate, at the end we move to "only-gait", unpredictably that's also give me 100% accurate result in identify a person.

5. Conclusion

At the end of extensive research with a set of experiments; it clearly found the need and applicability of biometric identification or verification system is in high demand in GCC. But scope of those existing system is very limited. National security like national surveillance security in need of more research to come-up with solid and feasible security system by complying national rules and regulations. Finding of this paper can be an inspiration for the stated region to apply gait based security system or at least it will open a door to think of it. Similarly, a number of constraints also highlighted with possible solution. Another significant finding of this research is acceptability is proven by considering the established research that are reported or available around us. But adaptability still is question mark in some areas. However, there are huge scope in future to dig-down the applicability of such system by following the country or national security system rules and regulation.

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